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For: PROJECTION OPTICAL SYSTEM AND PROJECTION TYPE DISPLAY
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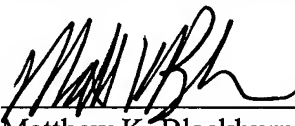
In support of the Amendment and Request for Reconsideration in response to the office action dated February 21, 2003 which is being filed concurrently herewith, Applicant submits herewith an English language translation of Japanese Application No. 2001-005307 filed on January 12, 2001 to perfect a claim to priority under 35 U.S.C. §119 for the above-referenced application. Applicant notes that the present application claims a foreign priority under 35 U.S.C. §119 based on the Japanese reference for which a certified priority document was submitted April 3, 2002.

Applicant believes that no fee is due for this submission, however, in the event that a fee is due, the Commissioner is authorized to charge such fee(s) to Deposit Account No. 13-4500, Order No. 1232-4808. A DUPLICATE COPY OF THIS PAPER IS ATTACHED HERETO.

Respectfully submitted,
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[Name of the Document] Specification

[Title of the Invention]

Projection type display apparatus

[What is claimed is]

[Claim 1]

A projection type display apparatus including a projection optical system for projecting image light from a display device, the apparatus comprising light amount adjusting means capable of substantially uniformly attenuating said image light in the cross-section thereof.

[Claim 2]

A projection type display apparatus according to Claim 1, wherein said light amount adjusting means has a variable stop comprising a plurality of tiltable light intercepting plates arranged in said cross-section.

[Claim 3]

A projection type display apparatus according to Claim 1, wherein said light amount adjusting means has a variable stop comprising a plurality of displaceable light intercepting plates arranged in said cross-section.

[Claim 4]

A projection type display apparatus according to Claim 1, wherein said light amount adjusting means has ND filter means variable in

transmittance.

[Claim 5]

A projection type display apparatus according to Claim 1, wherein said light amount adjusting means has a stop variable in aperture diameter.

[Claim 6]

A projection type display apparatus according to either one of claims 1 to 5, wherein a write signal to said display device is modulated in synchronism with the adjustment of the amount of light by said light amount adjusting means so that the dynamic range about luminance may change.

[Claim 7]

A projection type display apparatus according to either one of claims 1 to 5, wherein said display device includes a light modulating element and illuminating means for illuminating said light modulating element with light from a light source, and said illuminating means has a first optical system for forming a plurality of light source images by the light from said light source, and a second optical system for superimposing the beams from said plurality of light source images on said light modulating element, and said light amount adjusting means is disposed at a position whereat said plurality of light source images are projected.

[Claim 8]

A projection type display apparatus including a projection optical system for projecting image light from a display device, the apparatus comprising;

light amount adjusting means for adjusting the amount of said image light; and

control means for attenuating the amount of light of the whole of said image light by said light amount adjusting means and modulating a write signal to said display apparatus so that the dynamic range about luminance may be expanded.

[Claim 9]

A projection type display apparatus according to Claim 8, wherein said light amount adjusting means substantially uniformly attenuates said image light in the cross-section thereof.

[Claim 10]

A projection type display apparatus according to Claim 9, wherein said light amount adjusting means has a variable stop comprising a plurality of tiltable light intercepting plates arranged in said cross-section.

[Claim 11]

A projection type display apparatus according to Claim 9, wherein said light amount adjusting means has a variable stop comprising a plurality

of displaceable light intercepting plates arranged in said cross-section.

[Claim 12]

A projection type display apparatus according to Claim 9, wherein said light amount adjusting means has ND filter means variable in transmittance.

[Claim 13]

A projection type display apparatus according to Claim 8, wherein said light amount adjusting means has a stop variable in aperture diameter.

[Claim 14]

A projection type display apparatus according to Claim 8, wherein said projection optical system has said light amount adjusting means.

[Claim 15]

A projection type display apparatus according to Claim 8, wherein said display device includes a light modulating element driven in conformity with an image signal, and illuminating means for illuminating said light modulating element with light from a light source, and said illuminating means has a first optical system for forming a plurality of light source images by the light from said light source, and a second optical system for superimposing beams from said plurality of light source images on said light modulating element,

and said light amount adjusting means is disposed at a position whereat said plurality of light source images are projected.

[Claim 16]

A projection type display apparatus according to Claim 15, wherein said illuminating means has said light amount adjusting means.

[Claim 17]

A projection type display apparatus according to Claim 15, wherein said projection optical system has said light amount adjusting means.

[Claim 18]

A projection type display apparatus including a light modulating element for controlling the transmitted or reflected state of light to thereby display a gradation image; an illuminating device for applying light to said light modulating element; a projection optical system for projecting the transmitted light or reflected light of the light applied to said light modulating element, thereby displaying an image formed by said light modulating element, the apparatus comprising:

write signal processing means for modulation-processing a write signal to said light modulating element;

projection light amount control means for

controlling the amount of light in the optical path between the optical type integrator of said illuminating apparatus to said projection optical system; and

control signal generating means for controlling said write signal processing means and said projection light amount control means;

wherein said control signal generating means generates a control signal on the basis of the luminance level of an input image signal so as to make the amount of projection light great and the modulation of the write signal small when said luminance level is high, and to make the amount of projection light small and the modulation of the write signal great when said luminance level is low.

[Claim 19]

A projection type display apparatus according to Claim 18, wherein said projection light amount control means adjusts the amount of light in the optical path between said illuminating device to said light modulating element and/or between said light modulating element to said projection optical system.

[Claim 20]

A projection type display apparatus according to Claim 18 or 19, wherein said projection light

amount control means uniformly intercepts a light source image formed by said optical type integrator.

[Claim 21]

A projection type display apparatus according to either one of claims 18 to 20, wherein said projection optical system is a so-called schlieren optics.

[Claim 22]

A projection type display apparatus according to either one of claims 18 to 21, wherein said projection light amount control means has movable stop means and stop driving means.

[Claim 23]

A projection type display apparatus according to either one of claims 18 to 22, wherein said projection light amount control means is disposed at a position which is not in conjugate relationship with said light modulating element.

[Claim 24]

A projection type display apparatus according to either one of claims 18 to 23, wherein said projection light amount control means controls the amount of stop in conformity with the luminance level of the input image signal.

[Claim 25]

A projection type display apparatus according

to either one of claims 18 to 24, wherein the movable stop means of said projection light amount control means is a stripe stop, and the driving means is a cam motor or an ultrasonic motor.

[Claim 26]

A projection type display apparatus according to either one of claims 18 to 25, wherein said control signal generating means has luminance level calculation means for calculating the luminance level of the input image signal, and projection light amount calculation means for calculating the amount of projection light emerging from the projection optical system in conformity with said calculated luminance level, and generates the control signal of said projection light amount control means on the basis of the amount of projection light calculated in said projection light amount calculation means, and generates the control signal of said write signal processing means on the basis of the luminance level calculated in said luminance level calculation means and said calculated amount of projection light.

[Claim 27]

A projection type display apparatus according to either one of claims 18 to 25, wherein said luminance level calculation means calculates the

maximum value of the luminance signal of each pixel in each field or each frame of an image signal as maximum luminance.

[Claim 28]

A projection type display apparatus according to either one of claims 18 to 27, wherein said luminance level calculation means calculates the cumulative histogram of the luminance signal of each pixel in each field or each frame of an image signal, and calculates a luminance level at which said cumulative histogram becomes constant or greater as maximum luminance.

[Claim 29]

A projection type display apparatus according to either one of claims 18 to 28, wherein said write signal processing means modulates the write signal so as to amplify it at an amplification factor substantially inversely proportional to said amount of projection light.

[Claim 30]

A projection type display apparatus comprising:

a projection optical system for projecting an image onto a screen; and

light amount control means for uniformly intercepting a light source image projected onto the pupil of said projection optical system.

[Detailed Description of the Invention]

[0001]

[Technical Field to which Invention belongs]

This invention relates to a projection type image display apparatus.

[0002]

[Prior Technology]

With the arrival of the multimedia age, image display apparatuses are used in all scenes. Particularly, a projection type image display apparatus is easy to widen its image plane and therefore, front projectors have spread for presentation use, etc. and rear projectors have spread for home theater use, etc.

[0003]

CRT's have heretofore been utilized as the light modulating elements of these projectors. In recent years, however, with the requirements for higher luminance and higher resolution, as light modulating elements suitable for these requirements, the utilization of liquid crystal panels and DMD's (digital mirror devices, see, for example, Japanese Patent Application Laid-Open No. 10-78550) is becoming the mainstream. A projection type image display apparatus utilizing the liquid crystal panel or the DMD illuminates the liquid crystal panel or the DMD as the light

modulating element with light from a light source, and forms transmitted light or reflected light from the liquid crystal panel or the DMD into an image on a screen through a projection optical system.

[0004]

Now, the projection type image display apparatus has not yet reached the quality of image of a direct view type CRT image display apparatus in high image quality display (display of which a feeling of quality is required). The high image quality (feeling of quality) referred to herein refers to a high dynamic range (high contrast and high gradation display). The direct view type CRT image display apparatus realizes a dynamic range of at least 10000 : 1 when it displays the entire image plane in black and white. On the other hand, the dynamic range of the projection type image display apparatus is determined chiefly by the characteristic of the light modulating element, and is about 300 to 400 : 1 in the case of the liquid crystal panel, and about 600 to 800 : 1 in the case of the DMD. This lowness of the dynamic range is attributable to the fact that in black display, in the case of a transmission type liquid crystal panel, leak light, and in the case of a reflection type liquid crystal panel or the DMD,

scattered light is projected and a dark state floats.

[0005]

So, in a projection type image display apparatus using a scattering type liquid crystal panel disclosed in Japanese Patent Application Laid-Open No. 7-84553, a large aperture diameter and a small aperture diameter are prepared in the stop of a projection optical system, and they are changed over in conformity with the kind of an input image to thereby make display improved in dynamic range possible.

[0006]

[Problems to be solved by the Invention]

However, the example shown in Japanese Patent Application Laid-Open No. 7-84553 suffers from the problem that the display improved in dynamic range is made possible, but luminance is lowered and the feeling of sharpness lacks.

[0007]

Also, there has been actualized the problem that by the aperture diameter being made small, the brightness distribution of a projected image is varied (usually the marginal portion becomes relatively dark).

[0008]

So, the present invention has as its object

to provide a projection type image display apparatus keeping the uniformity of brightness and the feeling of sharpness and yet achieving a high image quality called a high dynamic range.

[0009]

[Means for solving the Problems]

In a first aspect of the invention, a projection type display apparatus includes a projection optical system for projecting image light from a display device, and the projection optical system has light amount adjusting means capable of substantially uniformly attenuating the image light in the cross-section thereof.

[0010]

In the first aspect of the projection type display apparatus, the light amount adjusting means may have a variable stop comprising a plurality of tiltable light intercepting plates arranged in the cross-section.

[0011]

In the first aspect of the projection type display apparatus, the light amount adjusting means may have a variable stop comprising a plurality of displaceable light intercepting plates arranged in the cross-section.

[0012]

In the first aspect of the projection type

display apparatus, the light amount adjusting means may have ND filter means variable in transmittance.

[0013]

In the first aspect of the projection type display apparatus, the light amount adjusting means may have a stop variable in aperture diameter.

[0014]

In the first aspect of the projection type display apparatus, a write signal to the display device may be modulated in synchronism with the adjustment of the amount of light by the light amount adjusting means so that the dynamic range about luminance may change.

[0015]

In the first aspect of the projection type display apparatus, the display device may include a light modulating element and illuminating means for illuminating the light modulating element with light from a light source, and the illuminating means may have a first optical system for forming a plurality of light source images by the light from the light source, and a second optical system for superimposing the beams from the plurality of light source images on the light modulating element, and the light amount adjusting means may

be disposed at a position whereat the plurality of light source images are projected.

[0016]

In a second aspect of the invention, a projection type display apparatus having a projection optical system for projecting image light from a display device, the apparatus including:

light amount adjusting means for adjusting the amount of the image light; and

control means for attenuating the amount of light of the whole of the image light by the light amount adjusting means and modulating a write signal to the display apparatus so that the dynamic range about luminance may be expanded.

[0017]

In the second aspect of the projection type display apparatus, the light amount adjusting means substantially may uniformly attenuate the image light in the cross-section thereof.

[0018]

In the second aspect of the projection type display apparatus, the light amount adjusting means may have a variable stop comprising a plurality of tiltable light intercepting plates arranged in the cross-section.

[0019]

In the second aspect of the projection type display apparatus, the light amount adjusting means may have a variable stop comprising a plurality of displaceable light intercepting plates arranged in the cross-section.

[0020]

In the second aspect of the projection type display apparatus, the light amount adjusting means may have ND filter means variable in transmittance.

[0021]

In the second aspect of the projection type display apparatus, the light amount adjusting means may have a stop variable in aperture diameter.

[0022]

In the second aspect of the projection type display apparatus, the projection optical system may have the light amount adjusting means.

[0023]

In the second aspect of the projection type display apparatus, the display device may include a light modulating element driven in conformity with the write signal, and illuminating means for illuminating the light modulating element with light from a light source, and the illuminating means may have a first optical system for forming

a plurality of light source images by the light from the light source, and a second optical system for superimposing beams from the plurality of light source images on the light modulating element, and the light amount adjusting means may be disposed at a position whereat the plurality of light source images are projected.

[0024]

In the second aspect of the projection type display apparatus, the illuminating means may have the light amount adjusting means.

[0025]

In the second aspect of the projection type display apparatus, the projection optical system may have the light amount adjusting means.

[0026]

In a third aspect of the invention, a projection type display apparatus includes:

- a light modulating element for controlling the transmitted or reflected state of light to thereby display a gradation image;

- an illuminating device for applying light to the light modulating element;

- a projection optical system for projecting the transmitted light or reflected light of the light applied to the light modulating element;

- write signal processing means for modulation-

processing a write signal to the light modulating element;

projection light amount control means for controlling the amount of light in the optical path between the optical type integrator of the illuminating apparatus to the projection optical system; and

control signal generating means for controlling the write signal processing means and the projection light amount control means;

wherein the control signal generating means generates a control signal on the basis of the luminance level of an input image signal so as to make the amount of projection light great and the modulation of the write signal small when the luminance level is high, and to make the amount of projection light small and the modulation of the write signal great when the luminance level is low.
[0027]

In the third aspect of the projection type display apparatus, the projection light amount control means may adjust the amount of light in the optical path between the illuminating device to the light modulating element and/or between the light modulating element to the projection optical system.

[0028]

In the third aspect of the projection type display apparatus, the projection light amount control means may uniformly intercept a light source image formed by the optical type integrator.
[0029]

In the third aspect of the projection type display apparatus, the projection optical system may be a so-called schlieren optics.
[0030]

In the third aspect of the projection type display apparatus, the projection light amount control means may have movable stop means and stop driving means.
[0031]

In the third aspect of the projection type display apparatus, the projection light amount control means may be disposed at a position which is not in conjugate relationship with the light modulating element.
[0032]

In the third aspect of the projection type display apparatus, the projection light amount control means may control the amount of stop in conformity with the luminance level of the input image signal.
[0033]

In the third aspect of the projection type

display apparatus, the movable stop means of the projection light amount control means may be a stripe stop, and the driving means may be a cam motor or an ultrasonic motor.

[0034]

In the third aspect of the projection type display apparatus, the control signal generating means may have luminance level calculation means for calculating the luminance level of the input image signal, and projection light amount calculation means for calculating the amount of projection light emerging from the projection optical system in conformity with the calculated luminance level, and may generate the control signal of the projection light amount control means on the basis of the amount of projection light calculated in the projection light amount calculation means, and may generate the control signal of the write signal processing means on the basis of the luminance level calculated in the luminance level calculation means and the calculated amount of projection light.

[0035]

In the third aspect of the projection type display apparatus, the luminance level calculation means may calculate the maximum value of the luminance signal of each pixel in each field or

each frame of an image signal as maximum luminance.

[0036]

In the third aspect of the projection type display apparatus, the luminance level calculation means may calculate the cumulative histogram of the luminance signal of each pixel in each field or each frame of an image signal, and calculates a luminance level at which the cumulative histogram becomes constant or greater as maximum luminance.

[0037]

In the third aspect of the projection type display apparatus, the write signal processing means may modulate the write signal so as to amplify it at an amplification factor substantially inversely proportional to the amount of projection light.

[0038]

In a fourth aspect of the invention, a projection type display apparatus includes:

a projection optical system for projecting an image onto a screen; and

light amount control means for uniformly intercepting a light source image projected onto the pupil of the projection optical system.

[0039]

[Embodiments of the Invention]

An embodiment of the present invention will

hereinafter be described with reference to Fig. 1.

[0040]

An image display apparatus according to the present invention, as indicated by reference numeral 1 in Fig. 1, includes a light modulating element P for controlling the state of the transmission or reflection of light to thereby display a gradation image, an illuminating optical system BL1 for applying light to the light modulating element P, and a projection optical system PL1 for projecting the transmitted light or reflected light of the light applied to the light modulating element P, and is designed to project this projection light onto a screen, not shown, to thereby display an image.

[0041]

The image display apparatus further includes write signal processing means 10 for modulation-processing a write signal to the light modulating element, projection light amount control means 20 for controlling the amount of light transmitted through or reflected from the light modulating element, and control signal generating means 30 for controlling the write signal processing means 10 and the projection light amount control means 20.

[0042]

The control signal generating means 30 may preferably generate a control signal, on the basis of the luminance level of an input image signal:

- * so as to make the amount of projection light great and the modulation of the write signal small when the luminance level is high;

- * so as to make the amount of projection light small and the modulation of the write signal great when the luminance level is low.

[0043]

The projection optical system PL1 in the present apparatus may preferably be comprised of a so-called schlieren optics (inverse schlieren). Also, the projection light amount control means 20 is comprised of movable stop means 20a and stop driving means 20b, and is disposed at the pupil position of the projection optical system PL1 which is a position not in conjugate relationship with the light modulating element P. Also, an integrator type illuminating optical system is used as the illuminating optical system BL1, and a matrix-shaped light source image by an optical type integrator is formed at or near the position of the movable stop means 20a. As the optical type integrator, there is a kaleidoscope (also called a "rod type integrator") besides a fly-eye lens used in the present embodiment.

[0044]

The projection light amount control means 20 may preferably control the aperture amount by opening or closing the movable stop means 20a in conformity with the luminance level of the input image signal.

[0045]

Now, the above-described control signal generating means 30 is comprised of luminance level calculation means 30a for calculating the luminance level of the input image signal, and projection light amount calculation means 30b for calculating the amount of projection light emerging from the projection optical system in conformity with the calculated luminance level. The control signal generating means 30 may preferably generate a control signal for controlling the projection light amount control means 20 on the basis of the amount of projection light calculated in the projection light amount calculation means 30b, and generate a control signal for controlling the write signal processing means 10 on the basis of the luminance level calculated in the luminance level calculation means 30a and the calculated amount of projection light.

[0046]

The luminance level calculation means 30a may preferably calculate the maximum value of the luminance signal of each pixel in each field or each frame of the input image signal as maximum luminance. In this case, the maximum value can be calculated by comparing the input image signal in a field or a frame in succession.

[0047]

Alternatively, it may preferably calculate the cumulative histogram of the luminance signal of each pixel, and calculate a luminance level at which the cumulative histogram is constant or greater as maximum luminance. Here, if an image signal of which the luminance level in a field or a frame has a distribution shown in Fig. 4(a) or Fig. 4(b) is inputted, when the cumulative histogram is calculated from the higher luminance level, it becomes such as shown in Fig. 5(a) or Fig. 5(b). The luminance level at which this cumulative histogram reaches e.g. 5% of the total image plane is calculated as maximum luminance. Accordingly, it is 216 in the example of Fig. 5(a), and is 117 in the example of Fig. 5(b). The control stages of the movable stop means 20a can be rendered into 255 stages in accord with the gradation of the input image, but practically may be rendered into the order of 8 to 16 stages.

When the movable stop means is to be controlled at 8 stages, it is controlled at 7 of the 8 stages in the example of Fig. 5(a), and at 4 of the 8 stages in the example of Fig. 5(b), that is, so as to be 87.5% and 50%, respectively, of the maximum amount of light.

[0048]

Also, the write signal processing means 10 may preferably modulate the write signal so as to amplify it at an amplification factor substantially inversely proportional to the aforementioned amount of projection light.

[0049]

Now, as the light modulating element, mention can be made of an element using liquid crystal, MEMS (micro electromechanical systems) type element typified by the DMD of TI Co., or an element having a micromirror disposed therein. This light modulating element P may be of the transmission type or the reflection type.

[0050]

Also, the movable stop means 20a is a stripe stop which performs a stop operation by rotating plural stop vanes as shown in Figs. 2(a) and 2(b) about respective rotating shafts, and the stop driving means 20b is a cam motor or an ultrasonic motor for rotating the rotary shafts. Further, as

shown in Fig. 3, in the movable stop means 20a, a plurality of strip-shaped stop vanes constituting the stripe stop are formed at such a pitch as accords with the arrangement of the unit images of the aforescribed light source image.

[0051]

The action of the present embodiment will now be described.

[0052]

When a high luminance level (e.g. a maximum luminance level 255 on the assumption that the gradation of the input image signal is 8 bits) is now present in the input image signal, the dynamic range of the light modulating element P is all used and therefore is not subjected to the modulating process in the write signal processing means 10, and in the projection light amount control means 20, the movable stop means 20a is controlled so that the aperture thereof may become largest, and 100% of the light transmitted or reflected in the light modulating element P is used as projection light. At this time, unnecessary transmitted light or scattered light created by the light modulating element P emerges from the projection optical system PL1 through the aperture which has become largest, and black display floats. However, the human eyes relatively recognizes luminance with the maximum luminance in the image plane as the reference and therefore, when the luminance level of the display image plane is high, the float of black is not so conspicuous.

[0053]

On the other hand, when the luminance level of the input image signal is low (e.g. a maximum luminance level 128 on the assumption that the gradation of the input image signal is 8 bits), the used dynamic range of the light modulating element P is about 50% and the amount of light required for projection is 50%. Accordingly, the projection light amount control means 20 controls the aperture of the movable stop means 20a so that the amount of projection light may become 50%. Further, in this state, the entire displayed image becomes a dark display and therefore, the light modulating element P is subjected to the modulating process so as to amplify the signal so that the dynamic range of the light modulating element P may be used by 100% in the write signal processing means 10. That is, the dynamic range of the light modulating element P is used by 100% and the display of the amount of projection light 50% is effected. The amount by which the amount of projection light has been thus stopped down by the projection light amount control means 20 is compensated for by the write signal processing means 10, whereby a display keeping the actual display luminance level constant becomes possible. At this time, the unnecessary transmitted light or scattered light created by the light modulating

element P has its incidence onto the projection optical system PL1 suppressed by the aperture having become narrow. Accordingly, in this state, a display in which black is firm can be effected.

[0054]

The effect of the present embodiment will now be described.

[0055]

According to the present embodiment, when the amount of projection light is stopped down by the projection light amount control means 20, the incidence of the unnecessary scattered light from the light modulating element P onto the projection optical system PL1 is suppressed and a firmer black display can be effected. That is, the amount of projection light is controlled in conformity with the maximum luminance level of the input image signal and also, the write signal of the light modulating element P is subjected to the modulating process, whereby it becomes possible to improve the floating of black display without changing the display luminance level, and a display in which the display dynamic range is enlarged relative to the luminance of 100% displayed in terms of a maximum amount of light can be effected.

[0056]

Also, when the luminance level of the displayed image is low, the input image signal is subjected to the modulating process and the image signal is expanded, whereby the gradation of the displayed image can be improved.

[0057]

Also, in the present embodiment, as previously described, a plurality of stop vanes constituting the movable stop means 20a are formed in accord with the arrangement of the unit images of the light source image by the integrator, and the stop vanes are rotated to thereby uniformly intercept each unit image and therefore, even in the case of the amount of projection light being freely stopped down, a uniform brightness distribution image is always obtained, and the enlarged projection image of the dynamic range under such a uniform brightness distribution becomes possible.

[0058]

The present invention will hereinafter be described in greater detail with respect to an embodiment thereof.

[0059]

(Embodiment)

In the present embodiment, use is made of the projection type image display apparatus as shown

in Fig. 1.

[0060]

In the present embodiment, a reflection type DMD panel P is used as the light modulating element, the panel P is illuminated by the illuminating optical system BL1, a movable stop (movable stop means) 20a and the projection optical system PL1 are disposed in the named order on the side toward which the light is reflected by the panel P, and a screen (not shown) for image projection is disposed forwardly thereof.

[0061]

Describing in greater detail, regarding the constituents of the illuminating optical system BL1, reference numeral 3 designates a reflector for a lamp, reference numeral 2 denotes a lamp (light emitting tube), reference numeral 4 designates a rotary color filter, reference characters 5a and 5b denote telecentric lenses, reference characters 6a and 6b designate fly-eye integrators, and reference numeral 7 denotes a condensing reflecting mirror. Also, the projection optical system PL1 is a so-called projection lens of a predetermined numerical aperture and a predetermined focal length (variable).

[0062]

The light emitted from the lamp 2 is first reflected and condensed by the reflector 3 and passes through the rotary color filter 4 at a condensing point, whereby it is converted into a color light (RGB or RGBW) and thereafter comes to the lenses 5a and 5b in its widened state. It is made telecentric by the condensing action of the lenses 5a and 5b and is subjected to the anteprocessing of the integrating action by the fly-eye integrators 6a and 6b and passes therethrough to the condensing and reflecting mirror 7, where it is reflected and condensed (by this condensing, the integrating action by the aforescribed fly-eye integrators 6 is realized) and uniformly illuminates the DMD panel P. The DMD panel P reflects only the image light of the thus illuminating beam in a direction to pass through the movable stop means 20a by the modulating action of each pixel mirror, and the image light is enlarged and projected onto a screen, not shown, through the projection optical system PL1. At this time, the matrix-shaped light source image by the fly-eye integrators 6 is formed at or near the position of the movable stop means 20a.

[0063]

Also, the movable stop means 20a, as shown in detail in Figs. 2(a) and 2(b), is a stripe stop in

which a plurality of stop vanes perform the stopping operation by the rotating operation thereof on the rotary shafts thereof, and the stop driving means 20b comprises a cam motor or an ultrasonic motor for rotating the rotary shafts. Further, as shown in Fig. 3, strip-shaped stop vanes constituting the stripe stop are disposed at such a pitch as accords with the arrangement of the unit images of the afore-described light source image 60.

[0064]

Also, in the present embodiment, a DMD panel is so-called RGB-sequentially driven, and this RGB sequential driving is synchronized with the rotation of the rotary color filter 4 so that a predetermined color light may illuminate the DMD panel.

[0065]

The write signal processing circuit 10 is connected to the DMD panel P, and the control signal generating circuit 30 is connected to the write signal processing circuit 10 and the stop driving ultrasonic motor 20b. The control signal generating circuit 30 has already been described and therefore need not be described any further.

[0066]

The action of the present embodiment will now

be described.

[0067]

Now, on the basis of the luminance level of the input image signal, the write signal to the movable stop means 20a and the DMD panel P is controlled so as to make the amount of projection light great and the modulation of the write signal small when the luminance level is high, and so as to make the amount of projection light small and the modulation of the write signal great when the luminance level is low.

[0068]

This operation will now be described with reference to Fig. 6. In Fig. 6, the luminance level on the axes of ordinates is such that luminance level relative to the gradation of the input image signal when 100% of the reflected light from the DMD was used with the stop fully opened is displayed at 8 bits. Here, however, for the simplification of description, it is to be understood that the luminance level linearly changes relative to the change in the gradation of the input image signal. When the maximum luminance level of the input image signal is calculated as 255, the stop is controlled so as to be fully opened in order to use 100% of the reflected light from the DMD, and the write signal

is not subjected to modulation. Next, when the maximum luminance of the input image signal is calculated as 128, the utilization of the reflected light from the DMD may be 50%. Accordingly, the stop is adjusted so that the amount of projection light may become 50%. At this time, by the amount of projection light being adjusted to 50%, the luminance level of the displayed image uniformly becomes 50%. For example, when the gradation of the input image signal was 127, the luminance level was 127 (point A in Fig. 6), whereas the luminance level becomes about 64 (point A' in Fig. 6). So, in order to compensate for this, the input image signal is modulated. Specifically, it will suffice to bring the point A' in Fig. 6 to a point A", and this can be accomplished by doubling the input image signal.

[0069]

Now, by the amount of projection light being stopped, the zero luminance level (=blackdisplay) can be lowered as indicated by ΔBK in Figs. 6A and 6B), as compared with a case where the amount of projection light is made great. That is, when the luminance level is low, the unnecessary scattered light from the DMD panel P is suppressed and a firmer black display is provided. Also, by the modulation of the write signal to the DMD panel P

being effected in conformity with the control of the amount of projection light, compensation is done so as to keep the medium luminance level of the displayed image constant.

[0070]

Also, regarding the quality, and particularly the uneven brightness, of the projection image, in the case of the present embodiment, as previously described, the stop vanes constituting the movable stripe stop 20a are disposed at such a pitch as accords with the arrangement of the unit images of the light source image 60 and therefore, when the stop vanes are rotated to thereby stop down the amount of projection light, the unit images are equally intercepted and therefore, there is no change in the number of the unit images by the stop amount, and a projection image of uniform brightness distribution is always obtained irrespective of the magnitude of the stop amount.

[0071]

The effect of the present embodiment will now be described.

[0072]

According to the present embodiment, when the maximum luminance level of the input image signal is low, a firmer black display can be effected without the medium luminance level of the

displayed image being changed. Accordingly, a display in which the dynamic range is expanded becomes possible by the contrast with the white display when the maximum luminance level of the input image signal is high.

[0073]

Also, the write signal to the DMD panel P is modulated so as to become great when the amount of projection light is controlled to a small amount, whereby it becomes possible to expand the gradational property of a low luminance level.

[0074]

Further, it becomes possible to effect such expansion of the dynamic range and the gradational property always under a quality of image having a stable and uniform brightness distribution.

[0075]

Now, while the present embodiment uses a vertical type movable stripe stop, this is not restrictive, but use can be made of any construction which equally stops down the unit images of the light source image (attenuates the amount of light), and for example, a horizontal type stripe stop, or an oblique stripe stop or a matrix-shaped one.

[0076]

Also, in the above-described embodiment, the

movable stripe stop is tiltable, but the numerical aperture thereof changes depending on the angle of the screen when the stop is tilted. Also, in the present invention, instead of the above-described movable stripe stop, use may be made of a variable stop in which a plurality of light intercepting plates variable in numerical aperture by being displaced by a control signal are arranged in the cross-section of the image light, a variable stop variable in aperture diameter by a control signal, or an ND filter variable in transmittance by a control signal.

[0077]

Also, while in the present embodiment, the DMD panel is used as the display device, this is not restrictive, but a liquid crystal panel of the transmission type or the reflection type can entirely likewise be handled.

[0078]

Further, while in the above-described embodiment, the projection light amount control means 20 adjusts the amount of light in the optical path from the panel P to the projection optical system PL1, this is not restrictive, but the projection light amount control means 20 may adjust the amount of light in the optical path between the fly-eye integrators 6 of the

illuminating optical system BL1 to the panel P, or the projection light amount control means 20 may adjust the amount of light in the optical path in the illuminating optical system BL1 and between the panel P to a screen, not shown.

[0079]

[Effect of the Invention]

As described above, according to the present invention, when the maximum luminance calculated from the image display signal is small, control is effected so as to lower the amount of projection light and also raise the level of the write signal to the light modulating element, whereby a firm black display can be effected while the display luminance level is kept constant. Accordingly, a display in which the display dynamic range is expanded by the contrast between the white display when the amount of projection light is made maximum and the black display when the amount of projection light is lowered can be accomplished in a state in which a uniform brightness distribution is maintained.

[0080]

Also, the gradation of the write signal of the light modulating element can be increased even at the same display luminance level and therefore, an improvement in the gradational property in a

low luminance level display can be accomplished also in a state in which a uniform brightness distribution is maintained.

[Brief Description of the Drawings]

[Fig. 1]

A view showing the system construction of a liquid crystal projector according to an embodiment of the present invention.

[Fig. 2]

A view showing the structure of a stripe stop according to the embodiment of the present invention.

[Fig. 3]

A view showing the layout relationship between the stripe stop according to the embodiment of the present invention and a light source image.

[Fig. 4]

Histograms showing the luminance level distributions of an input image signal.

[Fig. 5]

Cumulative histograms showing the luminance level distributions of the input image signal.

[Fig. 6]

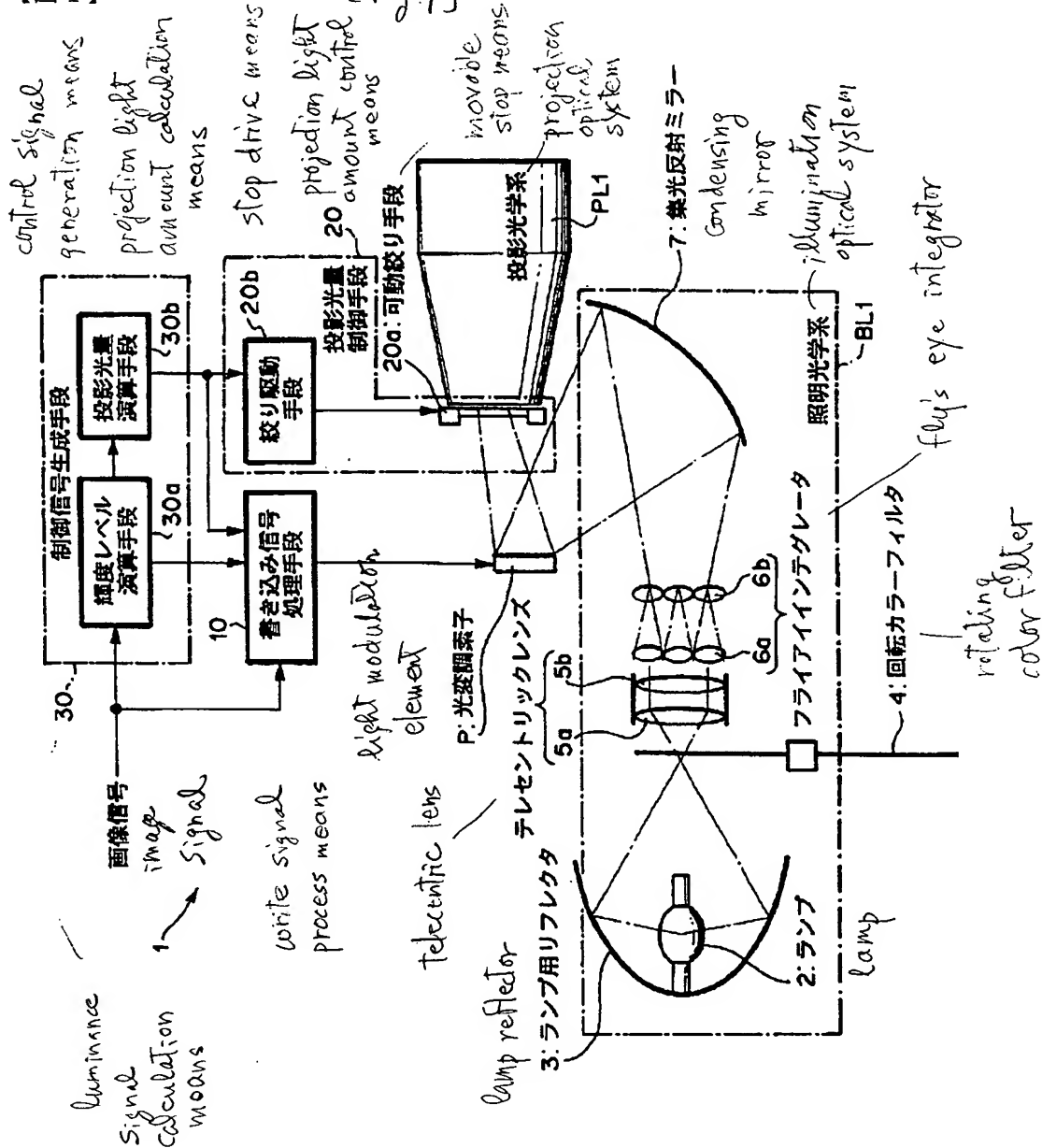
A view showing the modulation of a write signal into a light modulating element according to the embodiment of the present invention.

[Explanation of Symbols]

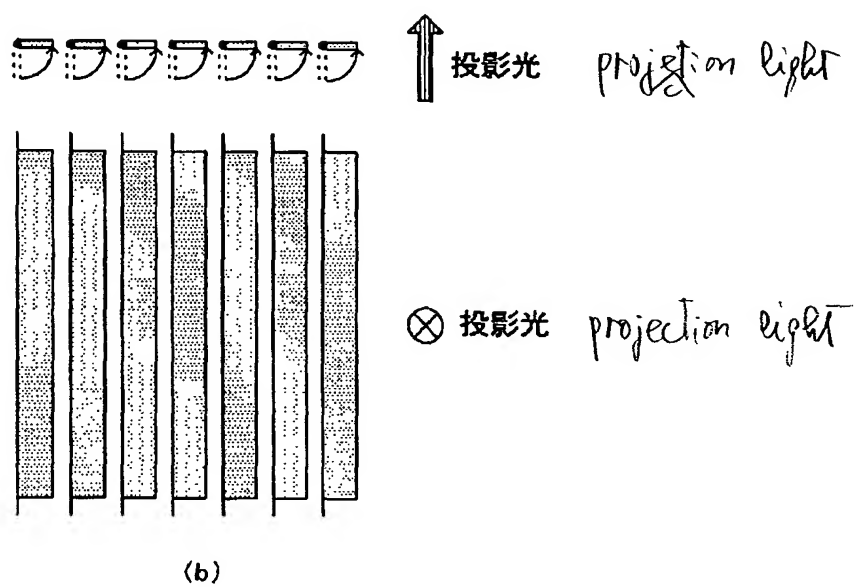
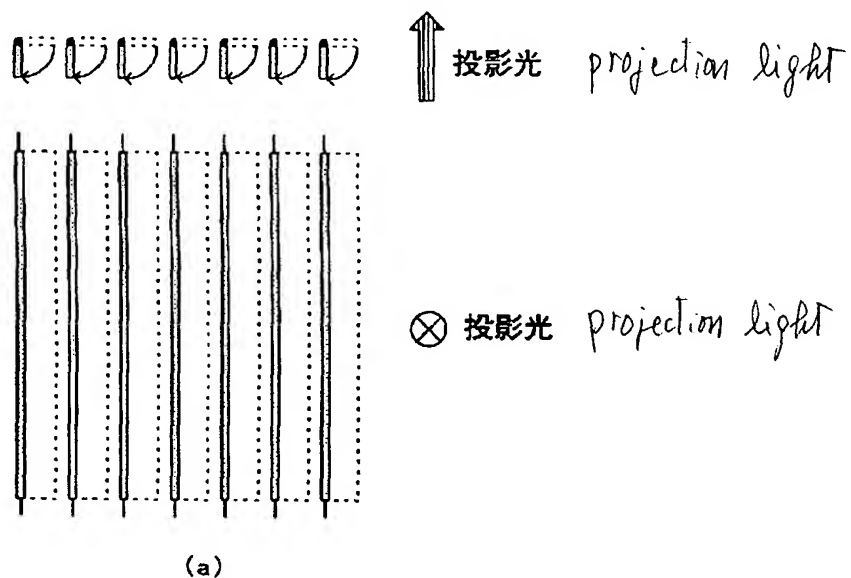
- 1 projection type display apparatus
- 2 lamp (light emission tube)
- 3 lamp reflector
- 4 rotating color filter
- 5a, 5b telecentric lens
- 6a, 6b fly's eye integrator
- 7 light condensing mirror
- 10 write signal processing means
- 20 projection light amount control means
- 20a movable stop means
- 20b stop drive means
- 30 drive signal generation means
- 30a luminance level calculation means
- 30b projection light amount calculation means
- 60 integrator light source image
- BL1 illuminating optical system
- P light modulation element
- PL1 projection optical system

【書類名】 図面 [Name of the Document] Drawings

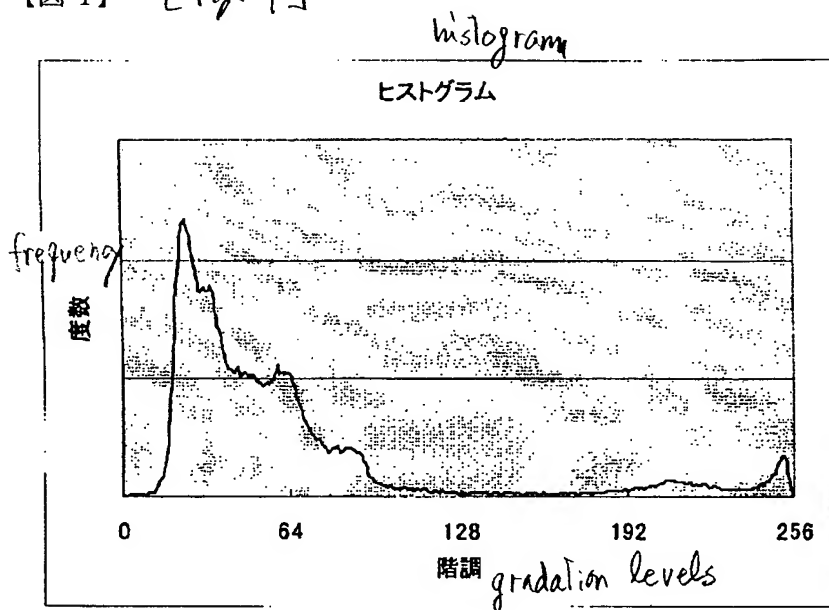
【図1】 [Fig.1]



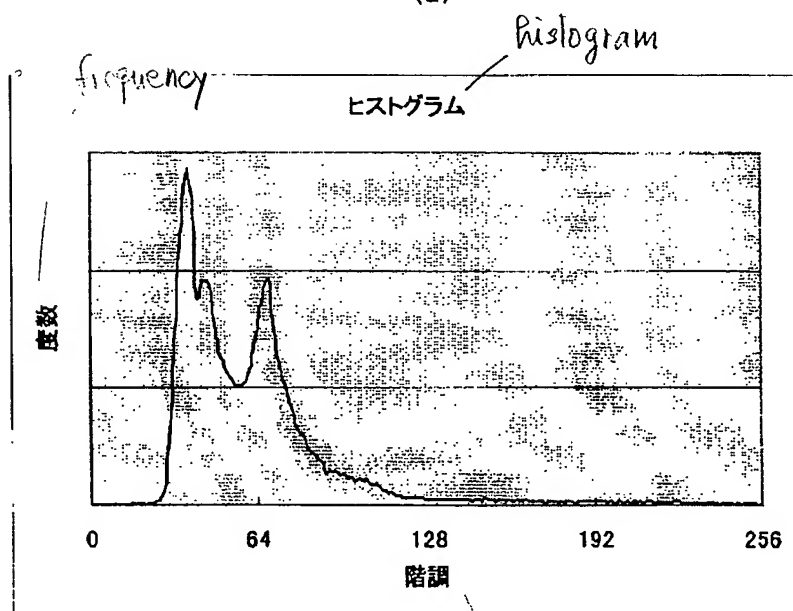
【図2】 [Fig. 2]



【図4】 [Fig. 4]



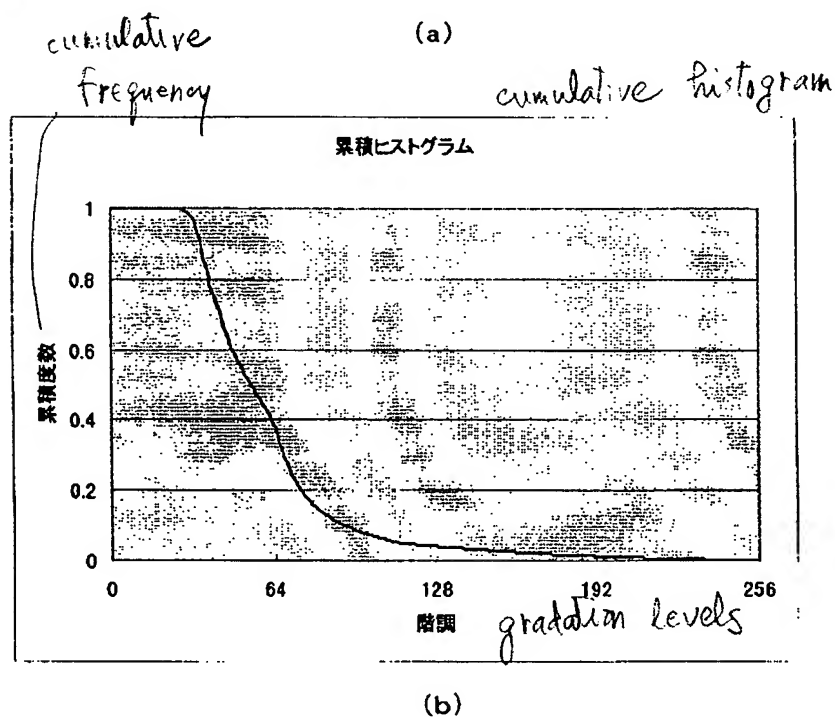
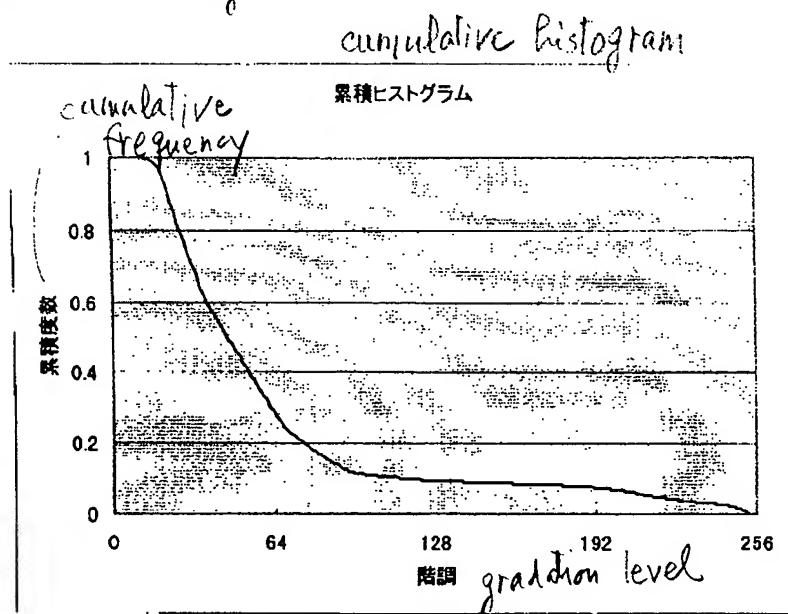
(a)



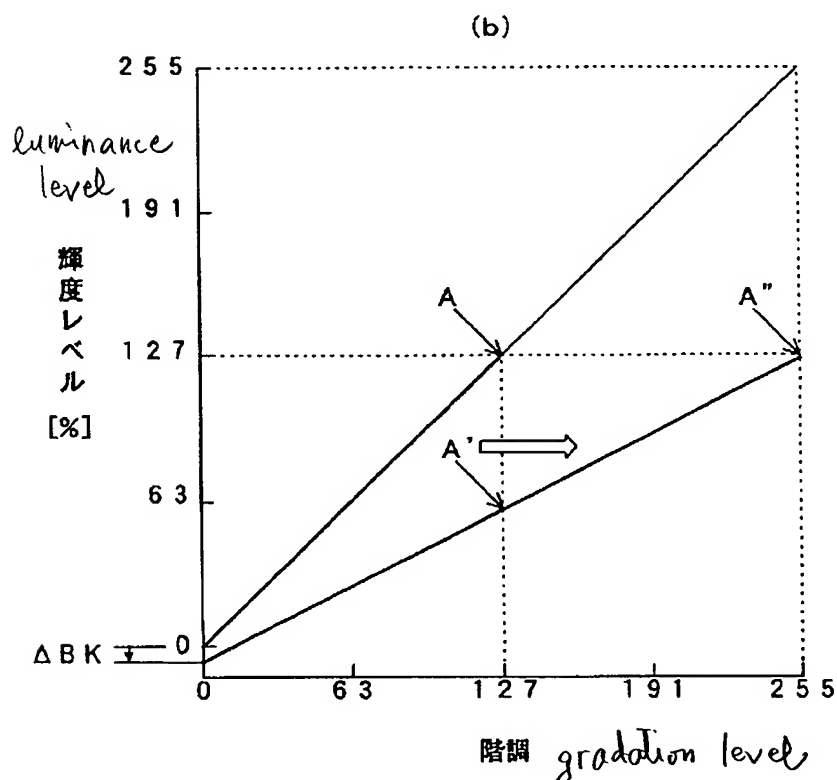
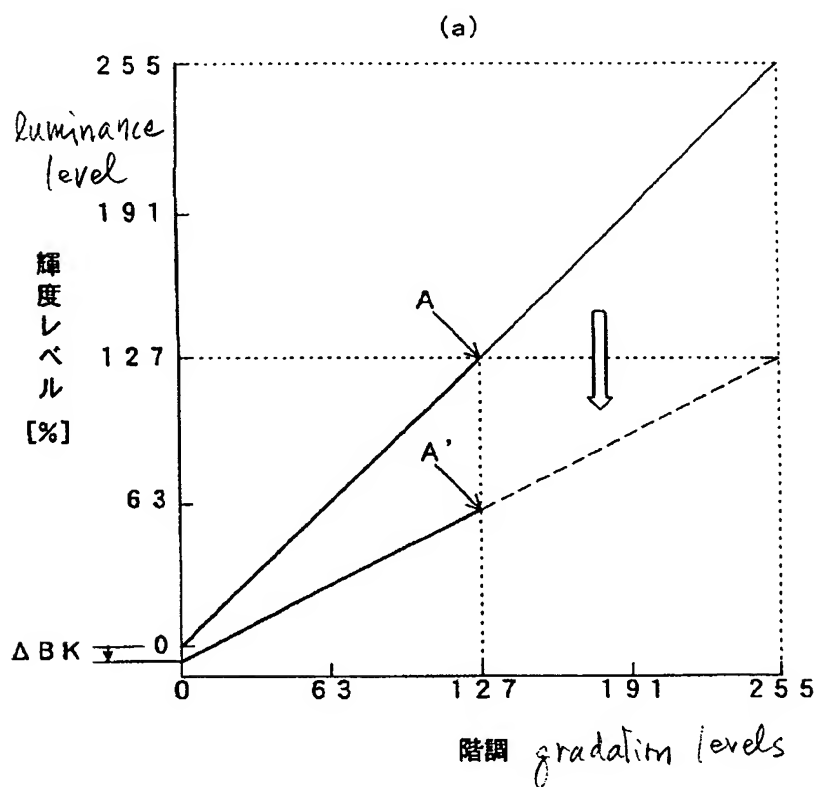
(b)

gradation levels

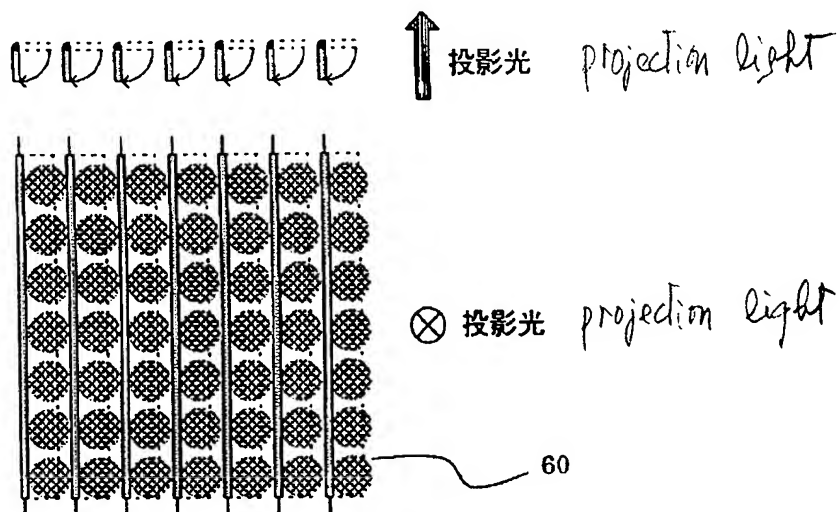
【図5】 [Fig.5]



【図6】 [fig. 6]



【図3】 [Fig. 3]



[Name of the Document] Abstract

[Abstract]

[Target]

In a projection type image display apparatus, to expand the dynamic range of display while maintaining the uniformity of brightness distribution.

[Solving means]

When movable stripe stop 20a matched with an integrator light source image is stopped down to make the amount of projection light small, the projection of unnecessary leak light or scattered light from a light modulating element P from a projection optical system PL1 is suppressed to provide a firm black display. So, the amount of projection light is controlled in conformity with the maximum luminance level of an input image signal to thereby expand the display dynamic range while a uniform brightness distribution is maintained by the contrast between maximum luminance display and the firm black display. Also, the write signal of the light modulating element is modulated in conformity with the control of the amount of projection light, whereby it becomes possible to expand the display dynamic range while compensating for the display luminance level.

[Selected Drawing] Fig. 1